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(54) Water soluble film.

(57) A water soluble film suitable for packaging caustic chemicals has an outer layer of a water soluble polymeric material, and an inner layer of a polymeric material which is compatible with the contents of a package made from the film. An intermediate layer can optionally be included to contribute to the tensile strength, bulk, or abuse resistance, or some other property of the film. Water soluble fillers such as salt can optionally be added to one or more of the polymeric materials, prior to or during extrusion of the film, to improve the processability of the film or its rate of dissolution in water, or to add a pigment to the film.

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The present invention relates to polymeric film, and more particularly to water soluble film suitable for packaging caustic materials.

Caustic or potentially hazardous materials such as detergents, soaps, pesticides and fertilizers are currently typically packaged in dispensers, such as high density polyethylene bottles, or other containers. After the chemical contents have been used, the dispenser or container must be disposed of in an environmentally safe way. This can be technically difficult and expensive.

Another concern with the use of such caustic or otherwise hazardous chemicals or pesticides is the safety of the user. In installing, using, and disposing of dispensers or containers containing such hazardous chemicals, the safety of the user can be jeopardized if the dispensing or storage system is not properly handled.

It is the object of the present invention to provide a convenient, effective way of storing caustic or potentially hazardous chemicals, pesticides and the like in a manner which satisfies both environmental and safety concerns.

The present invention provides a multilayer film which can effectively and efficiently store a quantity of a chemical, including caustic chemicals, and avoid the need of the end user to open a container to create access to the chemical material.

In one aspect of the invention, a water soluble film comprises an outer layer comprising a water soluble polymeric material; and an inner layer which comprises a polymeric material compatible with the contents of a package formed from the film.

In another aspect of the invention, a method for making a water soluble film comprises the steps of extruding an outerlayer of a water soluble polymeric material; extruding an inner layer of a polymeric material which is compatible with the contents of a package formed from the film; and joining the layers together to make the water soluble film.

In yet another aspect of the invention, a water soluble container comprises a film having an outer layer comprising a water soluble polymeric material; and an inner layer comprising a polymeric material which is compatible with the contents of the package when filled; the film being sealed together to form an enclosure.

The invention may be further understood with reference to the sole drawing, Figure 1, showing a cross-section of a film of the present invention.

Referring to Figure 1, a water soluble film 10 includes an outer layer 12 of a water soluble polymeric material.

This outer layer 12 may be a fully hydrolyzed polyvinyl alcohol (PVA) such as Vinex 1003 available from Air Products.

A feature of the fully hydrolyzed PVA of outer layer 12 is that it is insoluble in cold water but increasingly soluble in water at higher temperatures. Typically, at water temperatures above about 120°F fully hydrolyzed PVA such as the Vinex 1003 resin is fully soluble in water.

Outer layer 12 may also be a low melting point, water soluble coating. By "low melting point" is meant a melting point of between about 120 and 180°F, more preferably between about 130 and 170°F, even more preferably between about 140 and 160°F, and most preferably about 150°F.

Inner layer 16 includes a polymeric material which is compatible with the contents of a package made from the film. Layer 16 normally will be the innermost layer of a package formed from the film and therefore will be in contact with the caustic chemical, pesticide, fertilizer, etc. which is packaged. The term "caustic" is used herein to mean a chemical or mixture of chemicals with a pH of 7.0 or higher, i.e. alkaline.

Layer 16 can be any of a variety of polymeric materials, either polymers, copolymers, terpolymers, etc. which are compatible with the contents of a package formed from the film. By the phrase "compatible with" is meant that the composition of inner layer 16 is such that during normal storage and use, the material of layer 16 will not appreciably decompose or degrade as a result of contact with the package contents. Instead, the material of layer 16 will dissolve when the contents of the container are exposed to water. These contents can include highly caustic chemicals and detergents, pesticides, fertilizers, soaps, and other materials which can aggressively attack some packaging materials.

Suitable materials for layer 16 include acid/acrylate copolymers, preferably methacrylic acid/ethyl acrylate copolymer such as that available from Belland as GBC 2580 and 2600; styrene maleic anhydride copolymer (SMA)(available as Scripset (trademark) from Monsanto); ethylene acrylic acid copolymer (EAA), or metal salt neutralized ethylene methacrylic acid copolymer (EMAA) known as ionomer (available from du Pont), in which the acid content of the EAA or EMAA is at least about 20 mole percent; vinyl acrylate copolymer (Vinac (trademark)); cellulose; hydroxy propyl cellulose, such as that available from Aqualon as Kluceo (trademark); polyether block amide copolymer; polyhydroxy butyric acid or polyhydroxy valeric acid (available as Biopol (trademark)resins from Imperial Chemical Industries); polyethylene oxide; water soluble polyester or copolyester; polyethyloxazoline (PEOX 200 from Dow); and water soluble polyurethane.

Non-polymeric materials such as aluminum may be coated or sputtered onto the water-soluble layer 12.

An optional layer 14 can also be advantageously used in the inventive laminate. Intermediate layer 14 includes a polymeric material which contributes to the tensile strength of the overall water soluble film. An

especially preferred polymeric material for layer 14 is a partially hydrolyzed PVA such as Vinex 2034 available from Air Products. Preferred partially hydrolyzed PVA materials have a degree of hydrolysis of preferably at least about 60%, and more preferably at least about 70%. Most preferably, such partially hydrolyzed PVA materials are hydrolyzed at between 85 and 98% hydrolysis. Such partially hydrolyzed PVA materials are soluble in both cold and hot water.

An alternative material also suitable for intermediate layer 14 is polyethylene oxide, such as that available from Union Carbide as Poly Ox WSR.

Layer 14 can contribute to the tensile strength of the overall film, but also to such properties as bulk, abuse resistance, and the like.

The invention may be further understood by reference to the following examples.

Example 1

A fully hydrolyzed polyvinyl alcohol (Vinex 1003) was coextruded with a partially hydrolyzed polyvinyl alcohol (Vinex 2034), and a methacrylic acid/ethyl acrylate copolymer (Belland GBC 2580).

The annular coextrusion die was set at 400 to 410°F. The Vinex 1003 ran at a temperature of about 360 to 400°F (extrusion temperature). The Vinex 2034 resin ran at a temperature of about 375 to 420°F. The Belland GBC 2580 ran at a temperature of about 320 to 360°F.

The film of Example 1 had a total thickness of about 4.0 mils, with the outer layer of fully hydrolyzed PVA comprising about 1 mil; the intermediate layer of partially hydrolyzed PVA comprising about 2 mils; and the inner contents-compatible layer having a thickness of about 1 mil.

Example 2

A film like that of Example 1 is made, but including a water soluble filler in the inner layer.

Although the film of the present invention is preferably made by coextrusion techniques well known in the art, resins which are not suitable for coextrusion processes may be brought together by extrusion coating or conventional lamination techniques to produce the final water soluble film. Both discrete layers and coatings can be used for any of the layers of the inventive laminate.

As used herein "water soluble" refers to a film structure which is preferably totally water soluble. However, films which are substantially water soluble but have relatively minor amounts of a material in the film structure which is not water soluble; films with materials which are water soluble only at relatively high water temperatures or only under limited pH conditions; and films which include a relatively thin layer of water insoluble material, are all included in the term "water soluble".

The film of the present invention offers several advantages. The user does not have to open the package and therefore is not exposed to potentially hazardous contents. In addition, the conventional container is not recyclable and therefore can pose a hazard to the environment from residual contents within the container. The present invention offers a water soluble film which can be formed into a biodegradable package which can be used as is, with the appropriate contents within the package, and without the need for attempting to recycle a container.

In some instances, packages can contain premeasured portions so that no measuring is required and the package can be used as is.

Although the water soluble layer 12 of film 10 preferably is soluble only at relatively high water temperatures, other "triggering" mechanisms may be employed. For example, some resin materials may be water soluble at certain ranges of pH. Thus, resins such as the SMA and EAA or EMAA resins can be incorporated into the film structure at relatively low pH conditions, and thereafter formed into a container which is used in a high pH environment where the water soluble layer will decompose.

In instances where a resin is used which is soluble in water at relatively low temperatures, or is soluble in water at a broader range of pH conditions, the film may be protected from accidental failure (i.e. weakening or dissolving by water) by enclosing the package inside an overwrap material. Such overwrap materials in the form of bags, pouches or the like are well known in the art and are typically made up of polyolefin monolayer or multilayer films or laminates. These overwrap materials can also be made from paper, metal, and substances besides synthetic polymers.

In practicing the present invention, two problems can sometimes occur. First, these films can become tacky over time. Second, the rate of dissolution of the film can be slower than desired. These problems can be overcome to some extent by adding a water soluble filler to one or more resins making up the film. This is preferably done by compounding the agent as a powder into the base resin prior to or during extrusion.

Such fillers can solve the tackiness problem by acting as an antiblock, which reduces blocking and improves processing and converting operations.

Such fillers can also dissolve quickly, promoting dispersion of the polymer. This in turn increases the surface area of the material, speeding up dissolution.

When properly selected, these fillers can also function as a pigment.

Water soluble fillers meeting one or more of these properties (antiblock effect, increased dissolution effect, or pigment-bearing) are included in the base resin preferably in a masterbatch or "fully let down" form. The fillers are preferably of sufficiently small

particle size for conversion to film. A particle size of about 5 microns or less is preferred.

The water soluble fillers can be compounded into the base resin on conventional compounding equipment such as a twin screw. Stainless steel cooling belts can be used, instead of water, to cool and/or quench the resulting strands. Such belts are commercially available from Sandvik and Berndorf. The compounded resin can then be used in conventional extrusion operations to produce water soluble film.

Suitable water soluble fillers include any material which is water soluble, or substantially so, and capable of being incorporated into the film structures disclosed in this specification. Preferred materials are salts, and more preferably alkali or alkaline earth salts such as sodium carbonate (Na_2CO_3); sodium sulfate (Na_2SO_4); sodium chloride (NaCl); potassium carbonate (K_2CO_3); potassium sulfate (K_2SO_4); and potassium chloride (KCl).

One or more of these water soluble fillers can be included in one or more of the layers of the water soluble film of the invention. The filler can be present in any suitable concentration in a given layer. Optimal concentrations will be governed to some extent by the nature of the filler, the nature of the base resin, the specific end use of the film, processing and packaging equipment, and other factors. A preferred concentration of the filler or fillers for a given layer of the film is between about 100 parts per million (.01%) and 200,000 parts per million (20%) by total weight of the layer. Alternatively, the film as a whole may comprise from 0.01% to 20% by weight of a filler, such as a water soluble salt.

While the present invention has been described with reference to preferred embodiments, those skilled in the art will understand that modifications in resin choice, film structure, and process may be made without departing from the scope of the invention as claimed below.

Claims

1. A water soluble film comprising an outer layer which comprises a water soluble polymeric material; and an inner layer which comprises a polymeric material compatible with the contents of a package formed from the film.

2. A film according to claim 1 wherein the outer layer comprises fully hydrolysed polyvinyl alcohol, partially hydrolysed polyvinyl alcohol, polyethylene oxide or a low melting point water soluble coating.

3. A film according to claim 1 or 2 wherein the outer layer is water soluble at temperatures above about 49°C (120°F), but substantially water insoluble at room temperature.

4. A film according to claim 1, 2 or 3 wherein the inner layer comprises a polymeric material which does not degrade in the presence of caustic material.

5. A film according to any one of the preceding claims wherein the inner layer comprises a water soluble polymeric material.

6. A film according to any one of the preceding claims wherein the inner layer comprises acid/acrylate copolymer, styrene maleic anhydride copolymer, ethylene acrylic acid copolymer, ionomer, vinyl acrylate copolymer, cellulose, hydroxy propyl cellulose, polyether block amide copolymer, polyhydroxy butyric acid, polyhydroxy valeric acid, polyethylene oxide, polyester, copolyester, polyethyloxazoline, or polyurethane.

7. A film according to any one of the preceding claims further comprising an intermediate layer comprising a material providing tensile strength, bulk, or abuse resistance to the film.

8. A film according to claim 7 wherein the intermediate layer comprises a water soluble polymeric material.

9. A film according to claim 8 wherein the intermediate layer comprises fully hydrolysed polyvinyl alcohol, partially hydrolysed polyvinyl alcohol or polyethylene oxide.

10. A film according to any one of the preceding claims wherein at least one of the layers of the film comprises a water soluble salt.

11. A film according to claim 10 wherein the salt is an alkali or alkaline earth metal salt.

12. A film according to claim 11 wherein the salt is sodium carbonate, sodium sulfate, sodium chloride, potassium carbonate, potassium sulfate or potassium chloride.

13. A film according to any one of claims 10 to 12 wherein at least one of the layers of the film comprises from 0.01% to 20% by weight of the salt.

14. A film according to any one of the preceding claims which is sealed to itself to form an enclosure.

15. A method for making a film as claimed in any one of claims 1 to 14 comprising the steps of extruding an outer layer of a water soluble polymeric material; extruding an inner layer which comprises a polymeric material compatible with the contents

of a package formed from the film; and joining the layers together to make the water soluble film.

16. A method according to claim 15 further comprising the step of extruding an intermediate layer of a material providing tensile strength, bulk, or abuse resistance to the water soluble film; and disposing the intermediate layer between the outer and inner layers.

17. A method according to claim 15 or 16 further comprising the step of mixing a water soluble filler with at least one of the polymeric materials prior to, or simultaneous with, the extrusion of the outer and inner layers.

18. A water soluble container comprising a film as claimed in any one of claim 1 to 14.

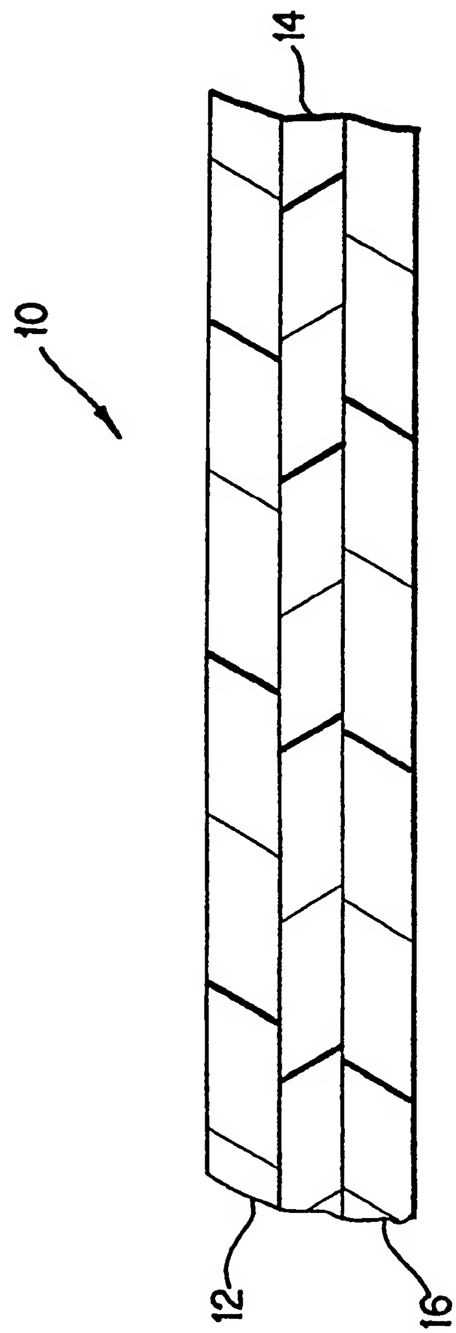

FIG. 1